Organic Seed Alliance
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PO Box 772, Port Townsend, WA 98368

Principles and Practices of Organic Lettuce Seed Production in the Pacific Northwest

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Crop History, Lifecycle, and Basic Biology

Lettuce (*Lactuca sativa*) belongs to the Asteraceae family (formally Compositae). Lettuce is a self-pollinating annual. Early in the season, it produces a dense rosette of leaves. As soil temperatures warms and days lengthen, its flower stalk forms and elongates. Lettuce is indeterminate and it will flower for up to two months.

Lettuce originated in a region occupying parts of Iran and Turkey and is likely a descendent of a wild lettuce (*Lactuca serricola*). Lettuce was reportedly grown in Egypt as long as 6000 years ago, and has been an important part of many ancient cultures, including the Egyptian, Greek, and Roman societies. Currently, lettuce is the best-selling salad vegetable. For many organic producers, lettuce is a high grossing staple for farmer's markets and wholesale.

There are seven classes of lettuce, distinguished by their morphologies and end uses: 1) Loose leaf, with a dense rosette of leaves arranged in a loose configuration, 2) Crisphead, with leaves that form in a tight, overlapping fashion, 3) Butterhead, with less compact and smaller leaves than the crisphead varieties, 4) Romaine or Cos, with upright, oblong clusters of coarse, thick leaves with large midribs that overlap into loose head-like structures, 5) Celtuce, stem lettuce or asparagus lettuce, grown for their thick, erect stem which is used as both a raw or cooked vegetable, 6) Latin, with elongated leaves and loose, semi-closed heads, and 7) Oilseed lettuce, with seeds that yield up to 35% oil is among the most ancient forms of this crop.

The majority of the lettuce seed produced in the United States comes from the coastal valleys of California. In the Pacific Northwest, lettuce seed has historically been produced in southwestern Idaho, in the Columbia Basin of Washington, and in Malheur County in Oregon.

Looseleaf lettuce

Crisphead lettuce

Butterhead lettuce

Romaine lettuce

Growing Lettuce Seed

Climatic requirements

Seed production of this dry seeded crop is best accomplished in a Mediterranean climate with a seasonal dry period for seed maturation and

harvest preferred for high quality seed. While the vegetable crop is thought of as a cool season crop, lettuce requires warmer temperatures than many of the other cool season, dry seeded crops, to fully realize its potential as a seed crop. The optimal climate for lettuce seed production is one with temperatures in excess of 70°F (21°C) to yield well, but extreme heat during flowering can damage the seed. Rain during harvest can cause seed shattering, sprouting of seeds in the seed heads, and encourage discoloration and diseases of the seed.

Higher temperatures and the longer daylength of summer often accelerate flower initiation and bolting in many lettuce types. Celtuce and heirloom varieties are usually the first to bolt, therefore easily maturing a seed crop in most suitable temperate areas. Conversely, many modern crisphead, butterhead, and cos types have been bred to be day neutral and are generally the most bolt-hardy, which can be problematic when trying to mature a seed crop in areas with shorter growing seasons.

Soil and fertility requirements

Ideally, lettuce grown for seed is grown in fertile, well-drained soils to minimize disease problems. If drainage is adequate then heavier soils such as a clay loam and silt clay loam soils are preferred, because they can better retain moisture and nutrients over the course of the long growing season.

The best approach to fertility management for an organic grower is to select a field with good tilth, balanced fertility, and adequate organic matter. Sufficient available phosphorus is important for early plant development and to produce good flowering and reproductive structure. Nitrogen should be adequate to promote plant growth and establish a good vegetative “frame”, but not excessive to avoid weak plants. If fertilizer is necessary then a 3:2:2 formula should supply sufficient nutrition. Because lettuce has relatively shallow roots, nutrients should be available in the top 12in (30 cm) of soil. Soil pH should between 6.0 and 6.5 to promote calcium availability.

Field Preparation and Planting

Soil preparation for lettuce seed should follow the same methods as for lettuce head production. The soil should be loosened to a depth of 12in (30cm), using a plow, tiller, or spader. A uniform, fine seedbed should be prepared. If flood irrigation will be routinely used, seedbeds should be well elevated to encourage drainage.

Depending on the type and variety, lettuce seed can require a long growing season. Because of this, planting is done as early in the spring as practical. Lettuce seed requires 35°F (1.7°C) for germination, and will be inhibited by temperatures above 91°F (33°C). Lettuce for seed production can be either direct seeded or transplanted. As in standard lettuce production, transplanting allows a longer growing season and additional pre-planting cultivation. In seed production, transplanting also provides an additional opportunity to rogue off-types before putting the transplants in the field.

Lettuce seed field is mulched with straw for weed control and planted on drip irrigation.

If direct seeded, lettuce is planted 0.5in (1cm) deep, at a rate of approximately 1.8lb/acre (2kg/hectare), spaced 2 – 3in (5 - 7cm) within rows and 18 – 30in (46 – 76cm) between rows. At four to six weeks after emergence, the lettuce is thinned within rows to the final spacing of 12 – 16in (30 – 40cm). Transplanted lettuce would be spaced at the final spacing of 12 – 16in (30 – 40cm) within row and 18 – 30in (46-76cm) between rows.

Cultivation and Irrigation

Lettuce has roots which are shallow and easy to disturb. Because of this, all cultivation should be done shallowly and gently. Initial weed pressure can be reduced by flushing weeds and cultivating prior to planting or transplanting. Mechanical cultivation can be done soon after planting, while the plants are still small. Cultivation should be between 1.5 – 4in (4 – 10cm) deep. If additional weed control is necessary later in the season, it can be done by hand.

Because lettuce has a shallow root system, available water needs to be present close to the soil surface. This is accomplished by frequent watering, commonly applied through overhead sprinklers during the vegetative stages of growth. Once the lettuce is flowering, water should not be applied to the canopy, because free moisture on the flowers and leaves can reduce pollination and increase the risk of disease. Many organic growers are now using drip irrigation systems to good effect but some still rely on overhead irrigation during the early stages of growth to establish a large, vigorous frame on their plants to insure good seed yields, before switching to drip for the reproductive stage of the crop's growth.

Lettuce seed produced on drip irrigation.

Flowering and Pollination

Lettuce is primarily self-pollinated. Its flowers are actually clusters of florets formed in a capitulum. Each capitulum contains 10 to 25 florets which are simultaneously fertile on a single day. Each floret, if successfully fertilized, will produce a single seed. Excessive heat can cause flowers in their effective pollination period to abort, missing the opportunity for seed set during that period.

Lettuce flowers.

Seed stalks form on lettuce based on the following conditions: day length, temperature, and plant age.

The specific requirements and relative importance of these traits vary considerably by variety. As a generalization, lettuce types will bolt in the following order (from earliest bolting to latest): celtuce, loose leaf, butterhead, romaine, crisphead. Depending on the breeding work done on individual varieties, this order may or may not hold true. In general, 70°F (21°C) is the minimum temperature necessary to form good seed stalks.

Because the leaves of crispheads and similar types are formed into a tight head of folded leaves, the seed stalk may not be able to emerge unassisted. An opening for the seed stalk is commonly made in two ways: 1) the top of the head is slashed lightly with a knife to produce a broad "X" cut, or 2) the top of the head is cracked by a sharp hit of the hand.

Isolation Requirements

Lettuce is a mostly self-pollinated crop; there is very little travel of airborne pollen. In order to avoid physical mixing of varieties at harvest, a minimum distance of 10ft (3m) between varieties should be observed. Commercial seed companies often require 20ft (6m) of separation. Certain environmental conditions, such as high humidity or the presence of foraging insects will increase the risk of cross-pollination. In these cases, growers should increase isolation distances to 150ft (45m) between varieties.

While lettuce is primarily self-pollinated it can cross with wild lettuce (*Lactuca seriola*). For this reason wild lettuce weeds should be monitored and removed within the lettuce seed field.

Multiple lettuce seed varieties may be planted in close proximity with alternate crops to separate them in the field. In this photo calendula acts as a break crop planted between different varieties.

Genetic Maintenance and Improvement

Population size

Lettuce is a self-pollinating and does not require large populations to maintain vigor. However, it is still necessary to maintain a large enough population to preserve the breadth of the variety's genetic diversity during seed production. Therefore, the recommended minimum population size depends on the initial diversity in the variety.

The following are guidelines based on the origin of the variety:

If the lettuce is a modern, "elite" variety, it likely was derived from a single plant. In this case, a minimum of 10 plants should be sufficient to maintain the genetic diversity.

Older commercial varieties (developed by university breeding programs or seed companies prior to 1980) have gone through many cycles of sexual reproduction. Therefore, these varieties have had an opportunity to evolve and diversify. With these varieties, seed should be saved from at least 20 to 50 plants, depending on the extent of variation present.

Finally, in the case of heirlooms, farmer derived varieties, and land races, if genetic conservation is a key goal then seed should be saved from at least 50 to 100 plants.

Selection criteria

The practice of genetic selection of any crop is related to the needs of the farmers in a particular area, environmental pressures, cultural practices, and market demands. When producing seed from stock seed (seed that has already been genetically refined) or under contract from a seed company, minimal roguing or selection may be required. Seed company guidelines should be communicated and followed regarding timing and extent of roguing activities. However, more intensive selection is an effective tool for improving cultivars over time and may be particularly useful in adapting a cultivar to local, organic growing conditions. While breeders normally concentrate on traits for the farmers who will grow the crop as a vegetable, it is also possible to select for traits important in seed production, a crucial component in adapting cultivars to organic systems.

Lettuce is typically selected for the following criteria:

Seedling vigor. Vigorous seedlings can be easily selected while they are still in flats. Select plants

based on rate of germination and rate of seedling growth. Selection for vigor at the seedling stage has repeatedly proven to improve seedling vigor for a number of crops when practiced over several cycles of selection.

Leaf color and color variation. When lettuce seedlings have produced 4 to 6 true leaves, the leaf color of individual plants can be evaluated. The colors and patterns should be selected to match the varietal norm.

Leaf shape. Leaf shape can be selected for when the plants have at least 8 to 12 true leaves. A number of shape components should be considered to determine if the plants are true-to-type: the degree of lobing, savoying, and blistering, and the overall shape.

Leaf texture. The texture of lettuce leaves can be best evaluated when the plants are close to maturity for vegetable harvest. Texture is primarily composed of leaf thickness and crispness.

Flavor. At harvestable size as a vegetable, flavor can be evaluated for sweetness, lack of bitterness, and any distinctive flavors that are characteristic of the variety.

Plant stature. Prior to transplanting or when lettuce has 8 to 12 true leaves, selection can be made based on if the plant has a more upright stature, with leaves away from the ground, or if the leaves are lying prostrate on the ground.

Head type. The degree of heading and tightness of the head can be evaluated at the time of vegetable harvest.

Disease resistance: Selection can be made throughout the growing season for resistance to the most common lettuce diseases, such as lettuce mosaic virus (LMV) and *Sclerotinia sclerotiorum*. These diseases will be discussed in "Diseases of Lettuce Seed Crops" section below.

Resistance to premature bolting. In general, it is important to select against early bolting in lettuce, because early bolting is deleterious for vegetable lettuce producers. However, caution must be taken with long-season varieties, such as crispheads, not to select so strongly for late bolting that the variety no longer bolts in the region where seed is being produced.

Seed Harvest

Lettuce seed matures between 12 and 21 days after flowering. On any given lettuce plant the flowers do not mature all at once, instead they mature sequentially. The expansion of the pappus from the beak of the seed, called feathering, signals seed cluster maturation. Seed harvest may begin when 30 - 80% of seed clusters display feathering, depending on methods and conditions.

Lettuce flowers feathered out.

For commercial seed production lettuce seed is normally harvested all at once, however on a small scale or with ample labor it may also be harvested multiple times in the field.

Multiple harvests. Harvesting repeatedly is typically done by hand. The first harvest occurs when one-third of the seed heads have feathered. Each plant is shaken into a sack or bucket. A second harvest is repeated in 1 to 2 weeks, when significant new feathering is visible. Sometimes, 3rd and 4th harvests can be made, but the seed may be unacceptably poor quality. Multiple hand harvesting can result in more seed yield, and higher seed quality. However, it requires more labor.

Single harvest - mechanical. When approximately 50% of the flowers have feathered, the crop is swathed. After 3 or 4 days, the seed is harvested and threshed with a combine. Harvest should happen in the late morning, so that residual

morning moisture can reduce losses due to shattering. The combine will either have pick-up guards on the header and a reel, or a belt pick-up without a reel. Because lettuce seed is small and delicate, the concave needs to be opened, the air needs to be set low, and the cylinder should be slow. Many growers find a 10 - 20% reduction in germination when lettuce is machine-harvested, both because immature seed is harvested and because mechanical threshers can damage the seed.

Lettuce field ready for swathing with 50% of flowers feathered out.

Single harvest – hand. An improved single harvest method has been developed by Gathering Together Farm in Philomath, Oregon. In their method, the lettuce plants are pulled and windrowed with the plant roots intact. Most of the plant, including the seed head, is placed onto geotextile landscape fabric to catch shattering seed. The plant roots are placed off of the fabric to avoid soil contamination in the gathered seed. The plants are harvested with the roots in order to continue providing energy to the maturing seedplants, which may continue to flower daily and mature seed for up to a week. The geotextile fabric wicks moisture away from the seed plants, but "breaths" and allows incidental rain to pass through, rather than puddle as it will with a tarp. The plants should be left to dry until the leaves are crisp. In the event of a forecast for prolonged precipitation, roots may be removed and plants rolled up into round "bales" that will shed rain for a few days of bad weather.

Once the seed plants are dry, threshing may begin. Threshing is best done early in the day, when residual morning moisture helps reduce losses due to shattering, and reduces presence of tiny stems ("sticks") as a seed contaminant. Threshing can be done mechanically or by hand with a rake or sticks.

Typical lettuce seed yields range from 200 to 1200lb/acre (178 to 1068kg/hectare).

Diseases of Lettuce Seed Crops

Fungal Diseases

Sclerotinia rot (*Sclerotinia sclerotiorum*)

Sclerotinia rot is caused by *Sclerotinia sclerotiorum* (and *Sclerotinia minor* in California), a pathogenic plant fungus. The symptoms of Sclerotinia rot are wilting of the lower leaves, followed by rotting of the base of the head.

Sclerotinia can infect a field through a number of mechanisms. The first is via wind, which can transport the fungus as spores, or carry infected soil or crop debris. The second is from contaminated machinery, such as tillage equipment or tractor tires. The third is from contaminated irrigation water, or rainwater traveling on across contaminated soil surfaces. The fourth method is via seed contaminated with sclerotia, the fruiting bodies of *Sclerotinia* spp.

Sclerotinia overwinters in the soil as sclerotia, which germinate when soil temperatures increase in the growing season. The disease progresses most quickly when the soil is moist, the air is

humid, temperatures are cool to moderate (59 - 68°F, 15 – 20°C) and some non-living plant debris, such as older leaves, and particularly senescent flower petals, exist in the field.

Sclerotinia can be managed 1) by crop rotation, 2) by avoiding saturated soil conditions, 3) by increasing airflow through increased row spacing or decreased plant populations, 4) by using clean seed, 5) by using lettuce varieties with horizontal resistance to this fuhgus, and 6) by using a recently introduced fungal biocontrol agent, marketed under the brand name Contans, that shows promise in eliminating *Sclerotinia sclerotia* from seed production fields.

Downy mildew *(Bremia lactucae)*
Downy mildew is caused by the parasitic fungus *Bremia lactucae*. The symptoms of downy mildew are initially yellow spots on the leaves, followed by cottony growth under the leaves, browning leaf lesions, and finally systematic infection of the heads and the roots.

Downy mildew will spread from infected plants to uninfected plants by rain-splash or wind. Cool temperatures and high humidity favor disease progression. A minimum of 5 to 7 hours of leaf wetness is required for infection and sporulation of the fungal pathogen. When conditions are favorable, downy mildew can rapidly infect a large area.

Downy mildew can be managed by; 1) crop rotation, 2) increasing airflow through increased row spacing or decreased plant populations, 3) using irrigation practices that minimize leaf wetness, or 4) using varieties with resistance to the pathogen. There are an ever increasing number of different races of downy mildew, and varieties will only be resistant if they either have resistance to all the races present in the growing area, or if they have adequate horizontal resistance to all races of downy mildew.

Powdery Mildew *(Erysiphe cichoracearum)*Powdery mildew on lettuce is caused by the fungus *Erysiphe cichoracearum*. It appears as a powdery growth on both sides of lettuce leaves.

Its growth is favored by warm, dry conditions. It seldom advances to a stage where it is economically damaging.

Gray Mold (*Botrytis cinerea*)Gray mold is caused by the fungus *Botrytis cinerea*. Symptoms first appear as soft and small yellow dots, becoming gray or tan. Later, thick gray mold may appear, starting at the lower, older leaves. In crisphead type lettuce, the inner leaves may become a slimy mass. The stem may become rotten at the base and break off.

Cool (60 - 77°F/15 - 25°C), damp, and poorly ventilated conditions favor disease progression, as well as abiotic stress and tissue damage. Long periods of overcast and drizzle are associated with gray mold outbreaks.

Gray mold can be managed by; 1) crop rotation, 2) increasing airflow through increased row spacing or decreased plant populations, 3) using irrigation practices that minimize leaf wetness, 4) using clean seed, and 5) removing plant debris from fields after harvest.

Gray mold on lettuce.

Viral Diseases

Lettuce Mosaic Virus (LMV)

LMV is a common potyvirus, and one of the most important viral diseases of lettuce due to its implications in lettuce production in certain regions. In the Imperial Valley, Coastal California Valleys, and Yuma Arizona where lettuce is monocropped on a large scale the spread of this virus can be devastating to production due to outbreaks of viral insect vectors that can cause the rapid spread of this disease. For this reason testing (indexing) for LMV is required for seed to be sold and planted in these regions. Outside of these production areas small amounts of LMV may not be a production issue of economic importance and the level of scrutiny in management of this disease should reflect the producer's intent in use or commercial sale of seed.

Symptoms appear first as pale veins ("vein clearing"), becoming a mosaic pattern in older tissue. The inner leaves of infected plants may be dwarfed and fail to form a tight heart.

LMV is a seedborne disease and infected seed can be a primary source of transmission. Wild hosts, such as wild lettuce (*Lactuca canadensis, Lactuca serriola, Lactuca spp.*) can also carry the disease and be a source of infection. Once present in a field, several species of aphids can spread the virus from infected plants to uninfected plants. The rate of spread of LMV depends on the initial number of infected lettuce plants or weeds, and on the number and activity of aphids.

A number of steps can be taken to manage the spread of LMV. The first step in is to reduce the chance of initial infection. Wild lettuce should be removed from areas surrounding the field. In certain areas, this may be prohibitively difficult. For example, disease free lettuce seed production is almost impossible in western Oregon because of the number of wild lettuce plants present. Additionally, lettuce seedlings may be screened for LMV prior to transplanting ("indexing"). At the 3 – 4 leaf stage, infected seedlings will appear lighter in color and stunted and can be removed from seedling trays. The second step is to reduce the spread of LMV by reducing the aphid population. To combat aphids, a regular schedule of field checks is important. If aphid-infested plants are discovered, they should be removed from the field, taking care to bag the plants first, so that aphids will not flee the infested plants. For crucial stock seed, lettuce is often grown in greenhouses, where the temperatures are high enough to prevent aphids from thriving. Some lettuce varieties possess *mo1*, a single-gene resistance to LMV; however, new strains of LMV can overcome this resistance.

Other Diseases

Aster Yellows Phytoplasma (AYP)

Aster yellows is a common phytoplasma disease. Symptoms include yellowing, blanching, or stub-like growth of the inner leaves. A characteristic symptom is the development of pinkish tan latex deposits under the leaf midribs. During the reproductive phases, seed heads may form with clustered growths of malformed and sterile flowers.

AYP is hosted by a large number of plant species, including many in the Asteraceae. It is spread primarily by the aster leafhopper (*Macrosteles quadrilineatus*) as well as many other species of leafhoppers. It overwinters in adult aster leafhoppers in the southern regions and is carried north annually with spring winds. Symptoms will progress more quickly and be more serious in warm or hot weather.

While the disease is difficult to manage a few steps can reduce its occurance. The spread and severity of the disease can be reduced by removing diseased plants from the field, removing plant debris from fields after harvest, and managing the insect vectors. Fortunately, the disease is not seedborne.

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Authors

Completed 2010
Jared Zyskowski, Organic Seed Alliance
Dr. John Navazio, Organic Seed Alliance
Frank Morton, Wild Garden Seed
Micaela Colley, Organic Seed Alliance
Jared Zyskowski, Organic Seed Alliance
PO Box 772, Port Townsend, WA, 98368
(360) 385-7192

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